Kansas Department of Transportation

TECHNICAL SUMMARY

Electric Vehicle Simulations Based on Kansas-Centric Conditions

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Introduction

While battery technology has improved significantly over the last decade, range anxiety is still a primary consideration for consumers when contemplating the purchase of an Electric Vehicle (EV) (Pevec et al., 2020). A recent survey by Autolist found that EV range tops the consumers' list of priorities (Autolist Analytics Team, 2021) with one of their earlier surveys indicating that the majority of respondents considered 300 miles of range to be sufficient (Voelcker, 2017). While most commercially available EVs are now able to achieve greater than 200 miles range, with the Tesla Model 3 sporting a 353 mile range according to the Environmental Protection Agency (EPA), the actual on-road range of EVs is based on a variety of factors (e.g., weather, weight, road grade, and cabin conditioning) and can be significantly different than the ideal conditions employed by the EPA during the Society of Automotive Engineers (SAE) J1634 test (77 ºF using a chassis dynamometer with the cabin conditioning system turned off) (SAE J1634, 2017). Thus, the varying range experienced by EV drivers can be problematic when designing a charging infrastructure to handle their range anxiety while considering the travel route and weather conditions (Ahn & Yeo, 2015). This is especially true in Kansas when considering the wide range of conditions encountered by Kansas drivers, in addition to being the second windiest state in the union (Samenow, 2016) while also encountering all four seasons with potentially significant rainfall and snow (Lin et al., 2017).

Given this wide variance in energy usage and corresponding EV range, it is important for local municipalities and state agencies to have a simulation tool that can estimate the range of commercial EVs in their local environment. This can then be used to facilitate the process planning of an effective charging station infrastructure. While extensive models exist for motors, batteries, air conditioning, and other aspects of EVs, this effort endeavors to generate a simple overarching model that includes all necessary variables to estimate the range of EVs on local roads based on the time of year. Overall, six commercial EVs were calibrated to their EPA stated range and parametric studies were completed to understand the different aspects that influence range over the following Kansas roads: I-70, I-35, US-54, and I-135. In addition, the model is employed to predict the range of an EV that is not commercially available yet as an exercise to understand how the real range of the vehicle in Kansas compares to the EPA stated range. The subsequent sections of this work include a description of the model developed, followed by a summary of the resulting parametric studies.

Project Description

Range anxiety continues to be a primary factor for consumers when considering the purchase of an EV. While numerous EVs now boast ranges greater than 200 miles based on EPA data generated from the SAE J1634 testing procedure, the actual range of the EV on-road can be significantly less. Weather, weight, road conditions and grade, along with cabin conditioning, all play a large role in decreasing actual driving distance. To account for these facets, this effort endeavored to create the simplest model that accounts for all pertinent factors to generate a more realistic outcome of EV range.

Project Results

Initial calibration of six commercial vehicles to the EPA stated range data finds good accuracy with the model deviating by only 0.45 and 0.57 miles for the highway and city ranges, respectively. Of the six vehicles, five were estimated to have state of charge (*SOC*) ranges deemed suitable within research findings. Subsequently, predicting a Chevy Bolt in simulated chassis dynamometer tests finds only a 1-2% loss in range due to added weight or tire pressure. However, simulating the impact of road grade, wind, and vehicle speed over a true highway environment demonstrated significant losses up to 43.2% of the EPA stated range for a Nissan Leaf. In addition, ambient temperature effects resulted in the Leaf requiring around two times the amount of charging events. Overall, model predictions indicate losses (city or highway) from 24.9%-57.8% at 20 ºF to 8.1%-37.5% at 95 ºF for the vehicles simulated.

Project Information

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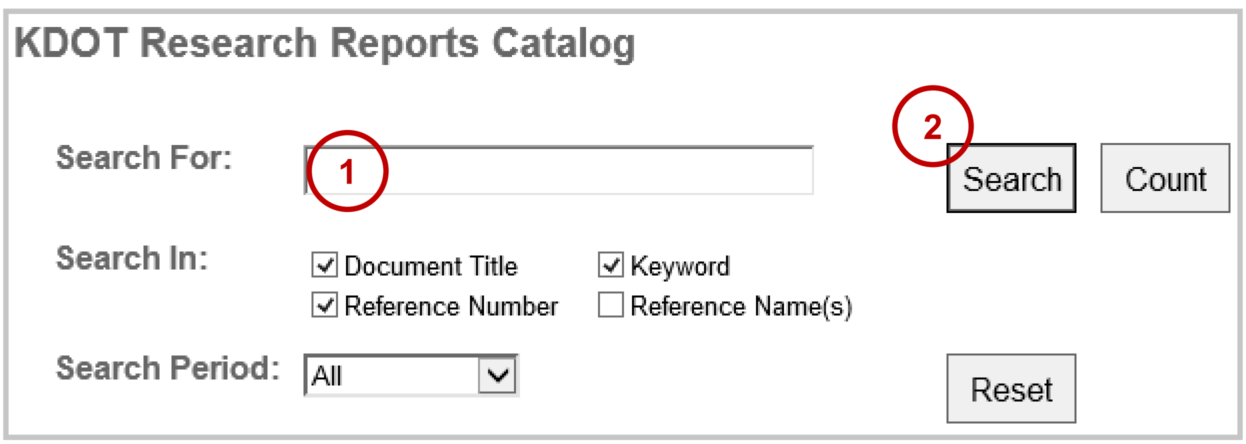

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